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(54) **METHOD OF IMBALANCE CORRECTION
USING A GROOVED DISK CLAMP**

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Irvine, CA (US)

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(57) **ABSTRACT**

(58) **Field of Classification Search**
CPC G11B 19/20; G11B 23/00
USPC 360/98.07; 369/264
See application file for complete search history.

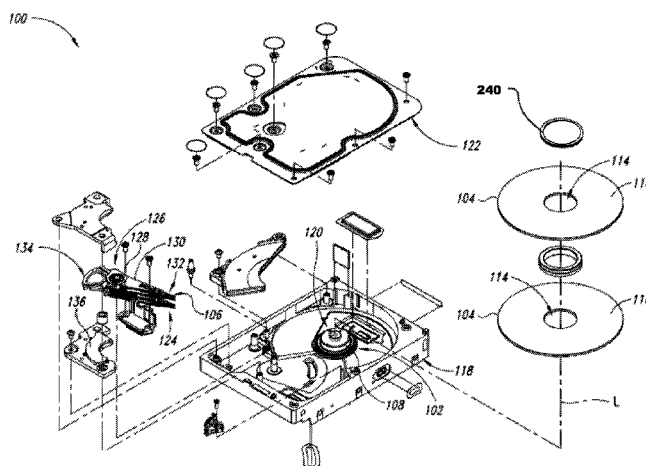
A disk clamp that can engage a disk hub to couple a disk
media to a disk hub, the disk clamp having a body portion, and
a groove formed in a surface of the body portion and extend-
ing at least in a circumferential direction substantially parallel
to at least a portion of the circumference of the disk clamp;
and a balance weight installed in the groove formed in the
surface of the disk clamp, the balance weight having a quan-
tity of material applied in the groove. A disk drive assembly
using the disk hub and a method of correcting a drive imbal-
ance using the disk hub.

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16 Claims, 10 Drawing Sheets



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Fig. 1A

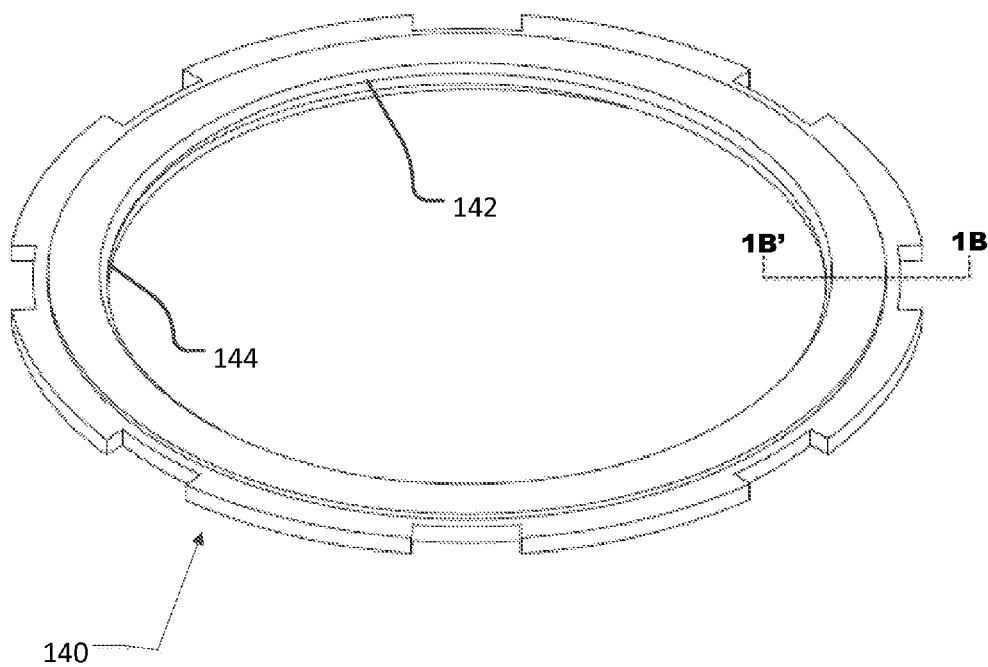
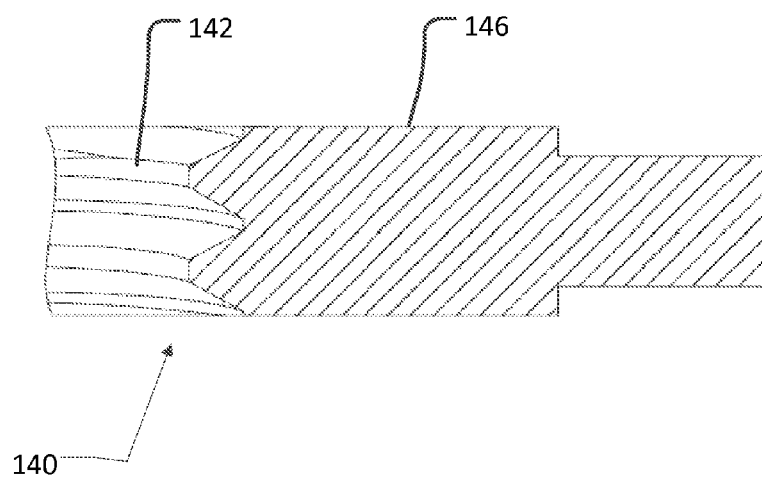


Fig. 1B



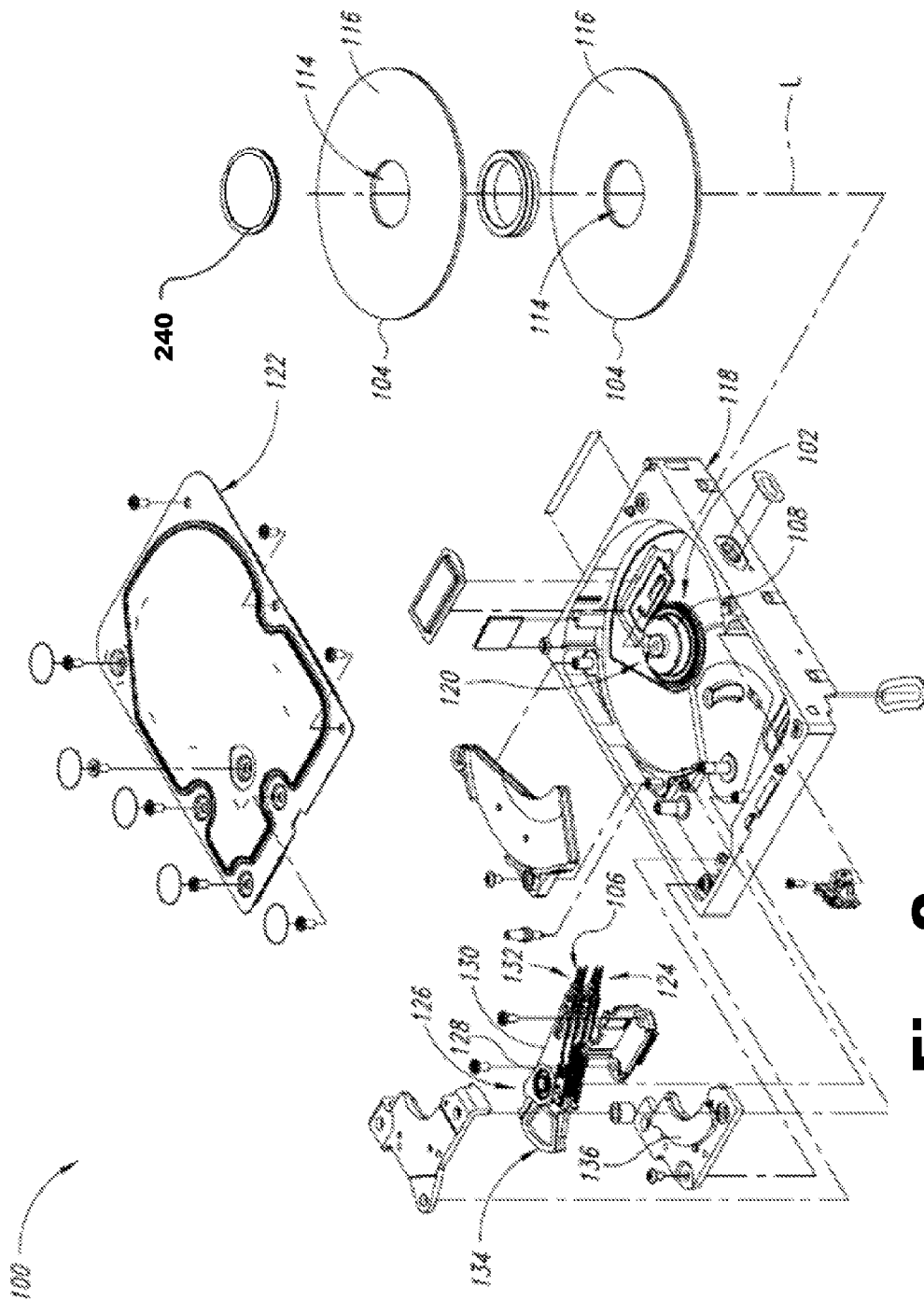


Fig. 2

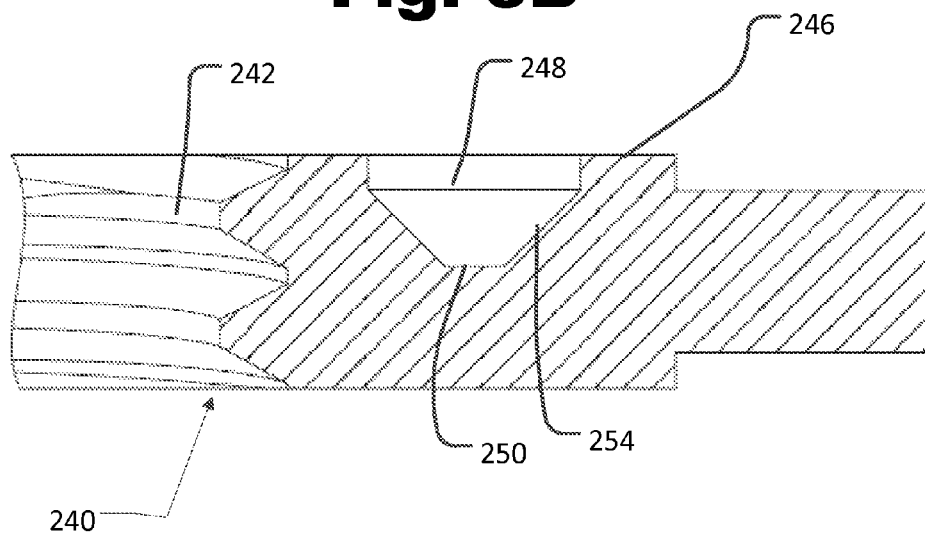


Fig. 4

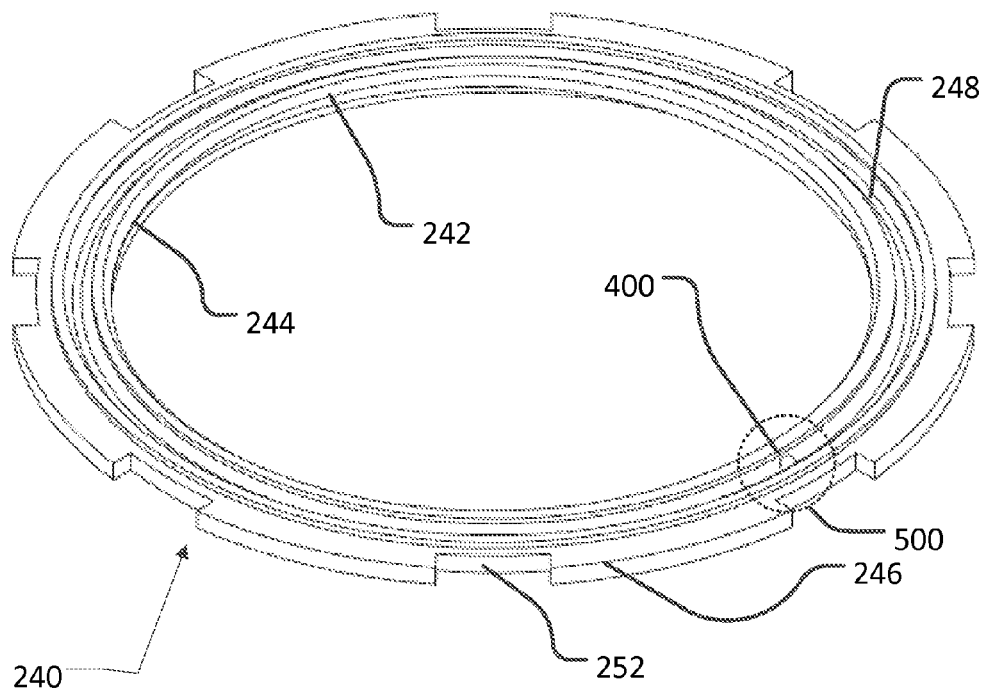


Fig. 5

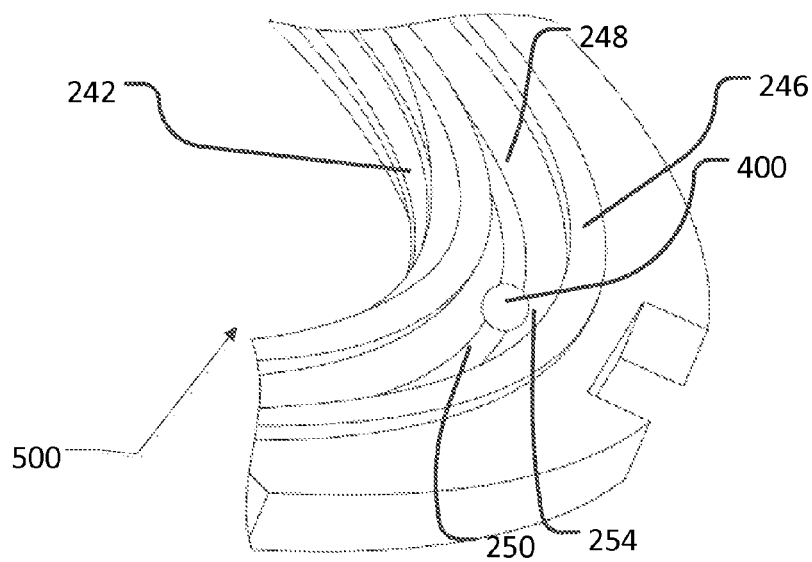


Fig. 6

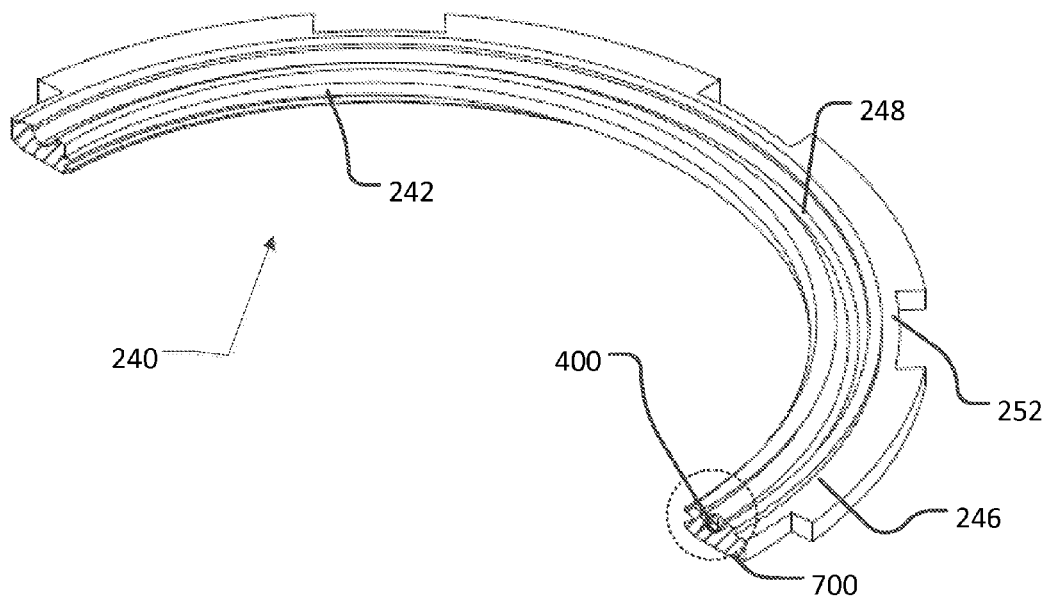


Fig. 7

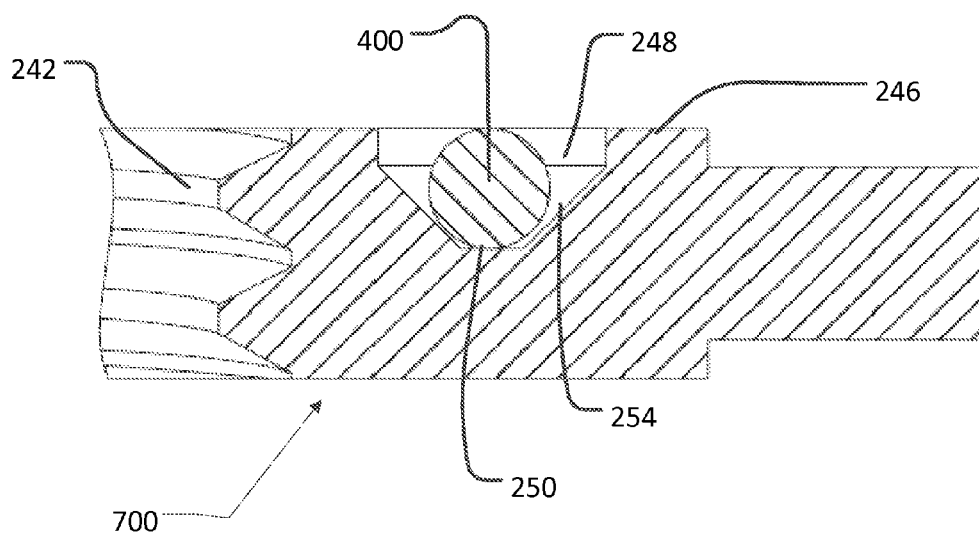


Fig. 8A

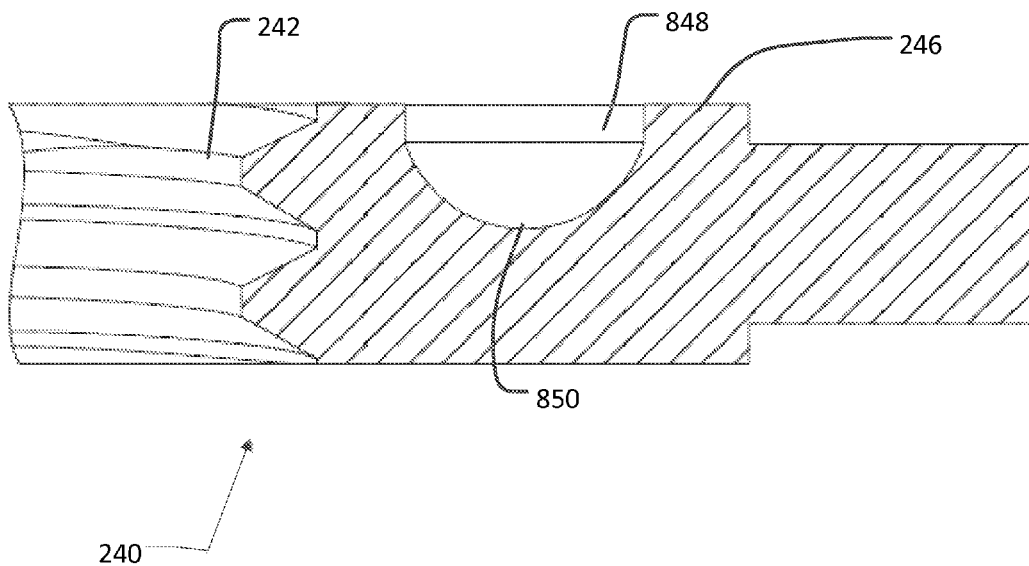


Fig. 8B

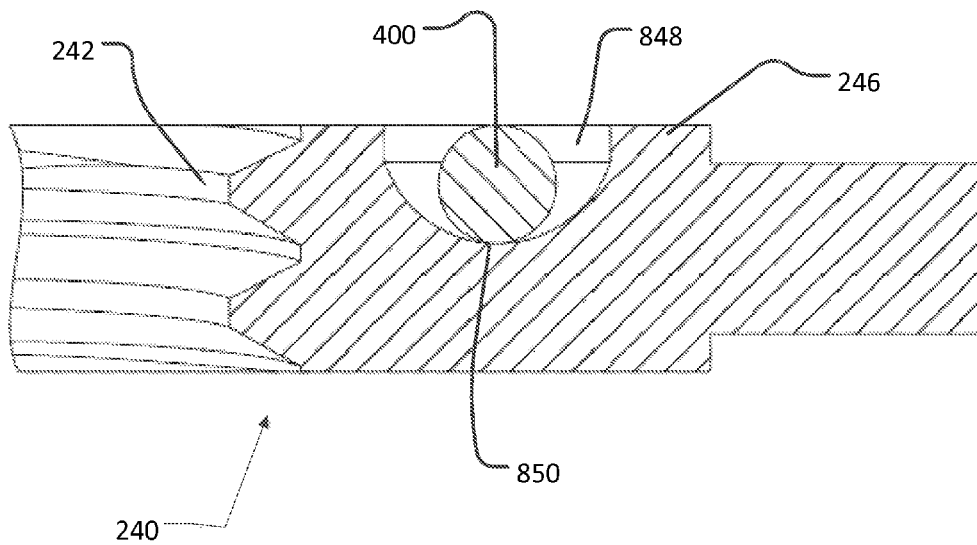


Fig. 9A

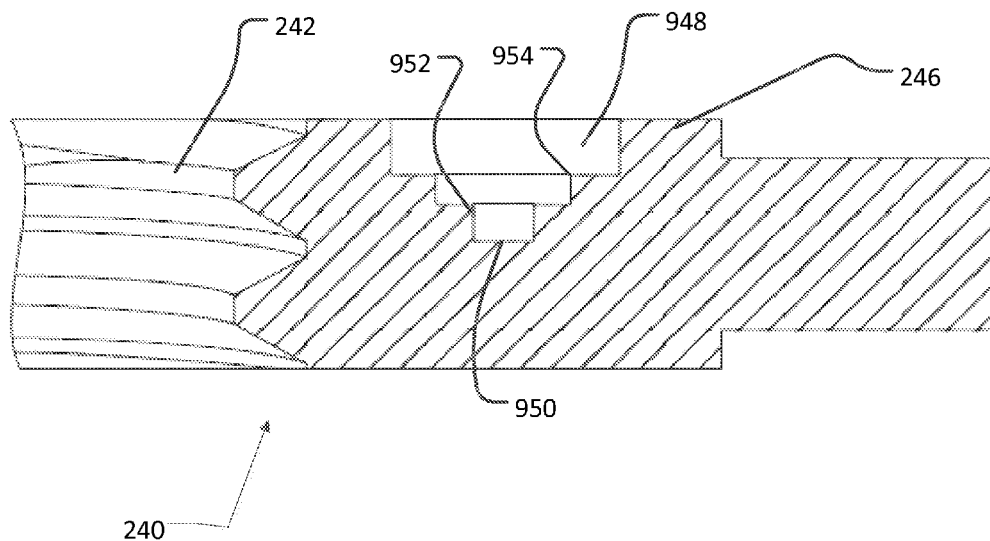


Fig. 9B

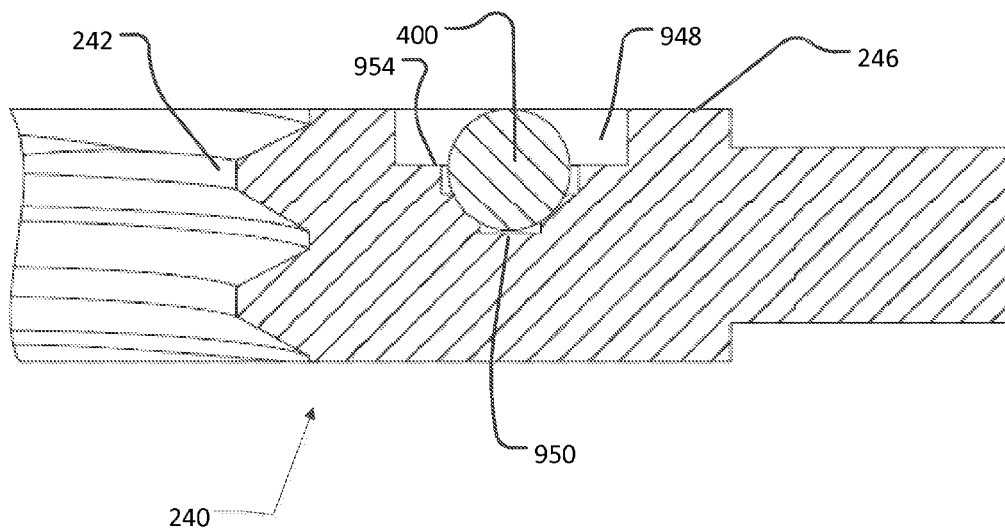


Fig. 10A

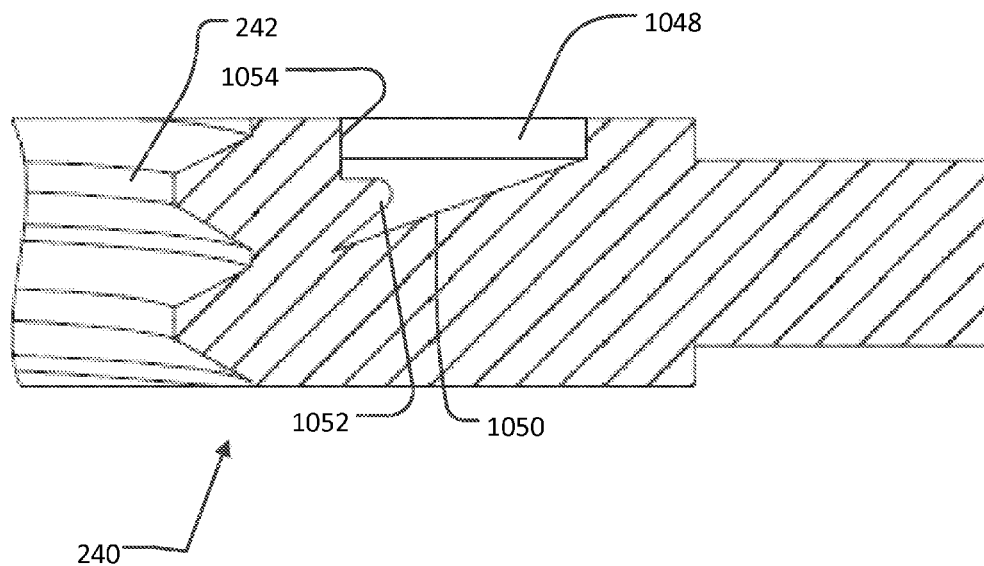


Fig. 10B

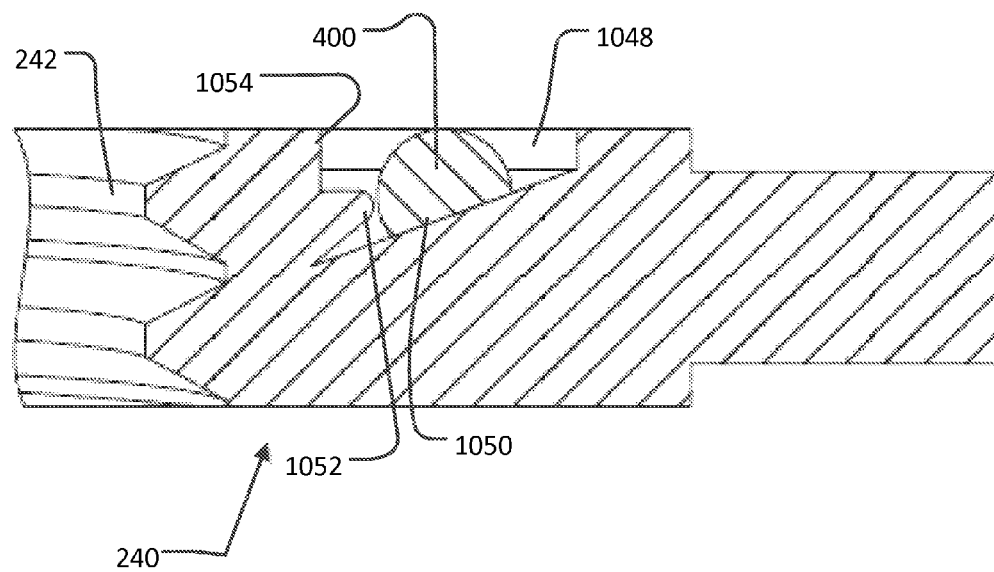
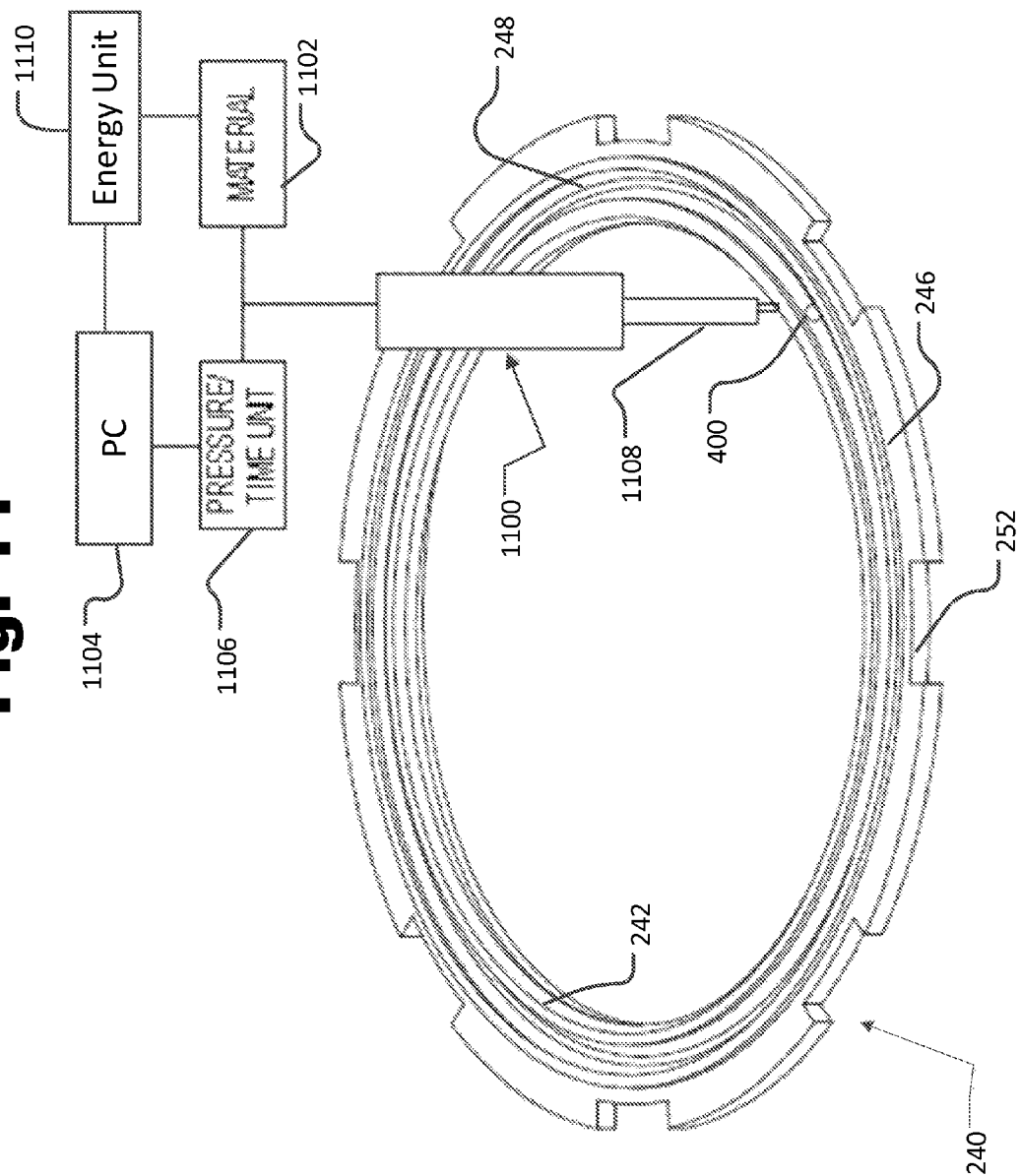
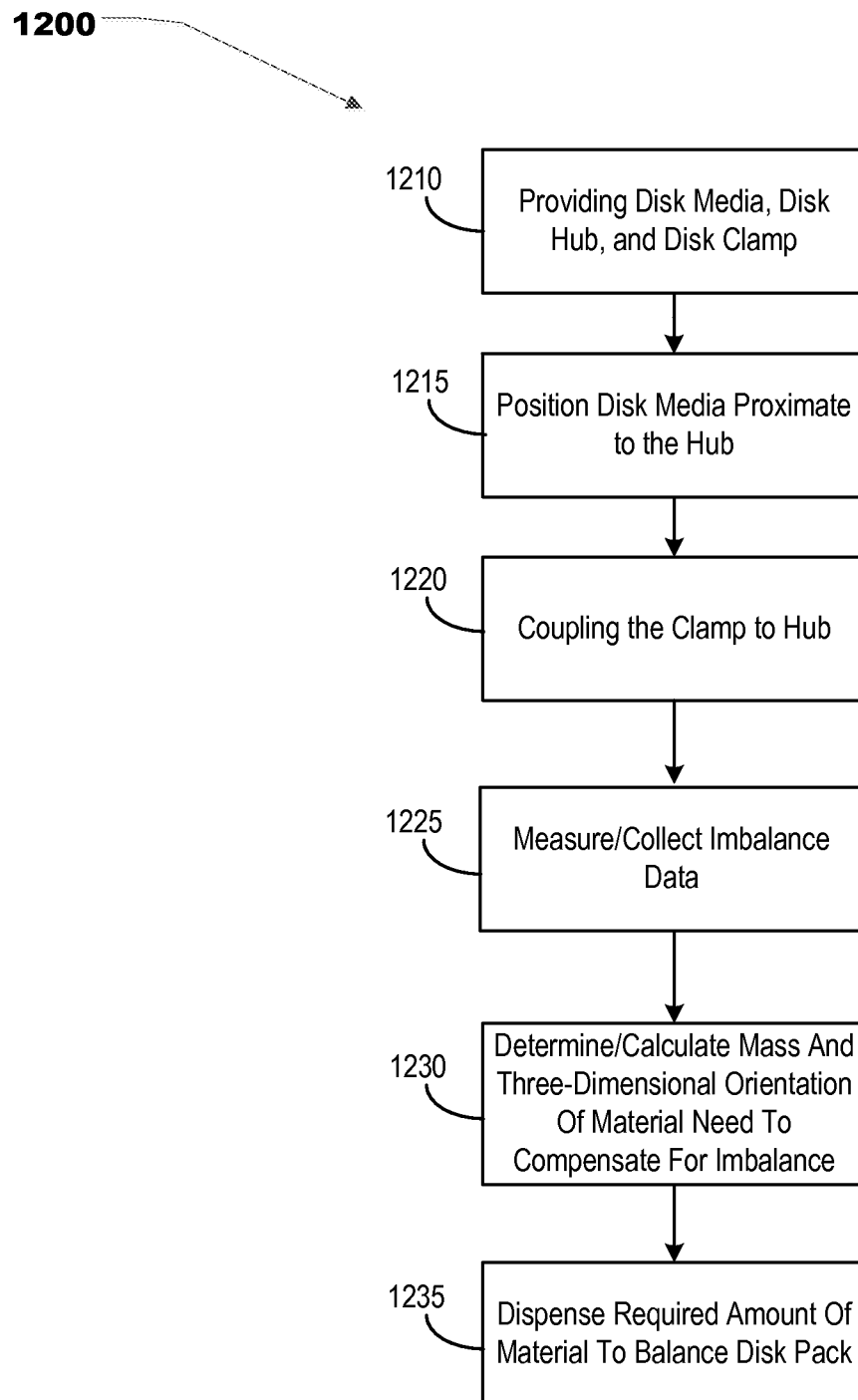


Fig. 11



**Fig. 12**

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METHOD OF IMBALANCE CORRECTION USING A GROOVED DISK CLAMP

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a divisional of U.S. application Ser. No. 13/672,668, filed Nov. 8, 2012, which is hereby incorporated by reference in its entirety.

FIELD

The present disclosure relates generally to information storage devices, and in particular to a disk drive having a disk clamp having a groove formed therein and a method of imbalance correction using the grooved disk clamp.

BACKGROUND

Disk drives typically include a disk clamp that provides a disk clamping force for holding one or more disks to a hub. Thus, disk clamping is becoming more and more important not only for regular Hard Disk Drives (HDD) performance but also under extreme conditions such as operational shock and non-operational shock. A reliable clamping force may maintain the integration of the whole disk pack, preventing the disk from separating or sliding under shock event.

FIGS. 1A and 1B show perspective and cross-sectional views of a related clamp **140** that could be used to provide clamping force. The clamp **140** has an annular shape and one or more threads **142** formed on a radially interior region **144** of the clamp. As shown in FIG. 1B, the clamp **140** also has a flat upper surface **146**.

Further, to reduce data streaming issues and vibrations during operation imbalances of the disk pack must be within certain imbalance tolerances. In order to correct or compensate for imbalance in the disk pack, plugs or wire pieces various size or shape may be inserted into holes provided in the disk hub to correct the mass distribution of the disk pack.

However, with decreasing form factors and tighter imbalance correction specifications, the effectiveness of using plugs or wire pieces inserted into holes provided in the disk hub to correct imbalance of the whole disk pack has been reduced.

There is therefore a need for an improved disk clamp design and imbalance correction method.

BRIEF DESCRIPTION OF THE DRAWINGS

A general architecture that implements the various features of the disclosure will now be described with reference to the drawings. The drawings and the associated descriptions are provided to illustrate embodiments of the disclosure and not to limit the scope of the disclosure. Throughout the drawings, reference numbers are reused to indicate correspondence between referenced elements.

FIG. 1A is perspective view illustrating a related disk clamp **140** for use in a hard disk drive assembly.

FIG. 1B is a cross-section view of the related disk clamp **140** taken along line 1B-1B'.

FIG. 2 is an exploded, perspective view generally illustrating a disk drive including an example clamp **240** according to one or more embodiments.

FIG. 3A is a perspective view illustrating a first example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. 2.

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FIG. 3B is a cross-section view of the first example embodiment of a disk clamp **240** taken along line 3B-3B'.

FIG. 4 is a perspective view of the first example embodiment of a disk clamp **240** with a quantity of material added for imbalance correction.

FIG. 5 is an enlarged perspective view of a portion **500** of the first example embodiment of a disk clamp **240** shown in FIG. 4 with the quantity of material added for imbalance correction.

FIG. 6 is a perspective view of the first example embodiment of a disk clamp **240** with a quantity of material added for imbalance correction with the disk clamp cut in half to show a cross-section.

FIG. 7 is cross-sectional view of the first example embodiment of a portion **700** of a disk clamp **240** shown in FIG. 6 with the quantity of material with the disk clamp cut in half to show a cross-section.

FIG. 8A is a cross-section view of a second example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. 2.

FIG. 8B is a cross-section view of the second example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. 2 with a quantity of material added for imbalance correction.

FIG. 9A is a cross-section view of a third example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. 2.

FIG. 9B is a cross-section view of the third example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. 2 with a quantity of material added for imbalance correction.

FIG. 10A is a cross-section view of a fourth example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. 2.

FIG. 10B is a cross-section view of the fourth example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. 2 with a quantity of material added for imbalance correction.

FIG. 11 is a perspective view illustrating an example apparatus applying the quantity of material to an example embodiment of a disk clamp **240** according to one embodiment.

FIG. 12 illustrates a flowchart for a method of manufacturing and correcting imbalance of a disk drive, according to one or more example embodiments.

DETAILED DESCRIPTION

Referring to FIG. 2, a disk drive **100** is illustrated, according to one embodiment. The disk drive **100** comprises a hub **102**, a disk **104** physically contacting and supported by at least one mounting surface (not labeled in FIG. 2) of the hub **102**, and a head **106** operable to write to and read from the disk **104**. In one embodiment, the hub **102** comprises a substantially cylindrical portion **108** which define a longitudinal axis L and a mounting surface (not labeled in FIG. 2) substantially normal to the longitudinal axis L, the mounting surface (not labeled in FIG. 2) extending radially outward.

As illustrated herein, the disk drive **100** comprises a magnetic disk drive, and the structures and methods described herein will be described in terms of such a disk drive. However, these structures and methods may also be applied to and/or implemented in other disk drives, including, e.g., optical and magneto-optical disk drives.

The disks **104** may comprise any of a variety of magnetic or optical disk media having a substantially concentric opening **114** defined there through. Of course, in other embodiments, the disk drive **100** may include more or fewer disks. For

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example, the disk drive **100** may include one disk or it may include two or more disks. The disks **104** each include a disk surface **116**, as well as an opposing disk surface not visible in FIG. 2. In one embodiment, the disk surfaces **116** comprise a plurality of generally concentric tracks for storing data.

As illustrated, the hub **102** may be coupled to and support the disks **104**. The hub **102** may also be rotatably attached to a motor base **118** of the disk drive **100**, and may form one component of a motor **120** (e.g., a spindle motor). The motor **120** and the hub **102** may be configured to rotate the disks **104** about the longitudinal axis **L**.

Further, a disk clamp **240** may be coupled to the hub **102** to provide a downward clamping force to the disks **104**. Specifically, the disk clamp **240** may be positioned above the disks **104** and attached to the hub **102**.

The disk drive **100** may further include a cover **122**, which, together with the motor base **118**, may house the disks **104** and the motor **120**. The disk drive **100** may also include a head stack assembly ("HSA") **124** rotatably attached to the motor base **118**. The HSA **124** may include an actuator **126** comprising an actuator body **128** and one or more actuator arms **130** extending from the actuator body **128**. The actuator body **128** may further be configured to rotate about an actuator pivot axis.

One or two head gimbal assemblies ("HGA") **132** may be attached to a distal end of each actuator arm **130**. Each HGA **132** includes a head **106** operable to write to and read from a corresponding disk **104**. The HSA **124** may further include a coil **134** through which a changing electrical current is passed during operation. The coil **134** interacts with one or more magnets **136** that are attached to the motor base **118** to form a voice coil motor ("VCM") for controllably rotating the HSA **124**.

The head **106** may comprise any of a variety of heads for writing to and reading from a disk **104**. In magnetic recording applications, the head **106** may include an air bearing slider and a magnetic transducer that includes a writer and a read element. The magnetic transducer's writer may be of a longitudinal or perpendicular design, and the read element of the magnetic transducer may be inductive or magneto resistive. In optical and magneto-optical recording applications, the head may include a mirror and an objective lens for focusing laser light on to an adjacent disk surface.

The disk drive **100** may further include a printed circuit board ("PCB") (not shown). The PCB may include, inter alia, a disk drive controller for controlling read and write operations and a servo control system for generating servo control signals to position the actuator arms **130** relative to the disks **104**.

FIG. 3A is a perspective view illustrating a first example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. 2. Further, FIG. 3B is a cross-section view of the first example embodiment of a disk clamp **240** taken along line 3B-3B'.

As illustrated, the clamp **240** has body **246** having a substantially cylindrical or annular configuration. Threads **242** may be formed on a radially inner surface **244** of the body **246** of the clamp **240**. These threads **242** may be configured to engage corresponding threads (not shown) performed on a disk hub **102** (shown in FIG. 2). In some embodiments, the body **246** also includes one or more notches **252** formed in a radially outer surface thereof.

Additionally, a groove **248** is formed in a surface of the body **246**. As illustrated in FIG. 3A, the groove **248** extends in a circumferential direction substantially parallel to entire the circumference of the disk clamp **240**. However, an exemplary embodiment is not limited to this configuration, and may

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instead extend substantially parallel to only a portion of the circumference of the disk clamp. In the example embodiment illustrated in FIG. 3B, the groove **248** has a quasi-V-shaped cross-section with angled sidewalls **254** and a substantially flat bottom **250**. However as discussed below other example embodiments are not limited to this cross-section configuration.

FIG. 4 is a perspective view of the first example embodiment of a disk clamp **240** shown in FIGS. 3A and 3B with a quantity of material added for imbalance correction. FIG. 5 is an enlarged perspective view of a portion **500** of the first example embodiment of a disk clamp **240** shown in FIG. 4 with the quantity of material added for imbalance correction. FIG. 6 is a perspective view of the first example embodiment of a disk clamp **240** with a quantity of material added for imbalance correction with the disk clamp cut in half to show a cross-section. FIG. 7 is cross-sectional view of the first example embodiment of a portion **700** of a disk clamp **240** shown in FIG. 6 with the quantity of material with the disk clamp cut in half to show a cross-section.

As mentioned above, the clamp **240** is illustrated as having a body **246**, threads **242** formed on a radially inner surface **244** of the body **246**, and a groove **248** formed in a surface of the body **246**. The groove **248** may be provided to allow balancing of a disk pack of a hard drive using the clamp **240**. As shown in FIG. 4, a portion of material **400** has been inserted into the groove **248** to adjust the mass of the disk pack on which the clamp **240** is mounted so as to correct any imbalance in the assembled disk pack.

In the example embodiment of FIGS. 4-7, the portion of material **400** is shown as having a substantially spherical shape. However, an example embodiment is not limited to this particular structure and may include alternative structures such as a tear-dropped shaped structure or a hemi-spherical shaped structure. Additionally, in the example embodiment of FIGS. 4-7, the portion of material **400** is shown being positioned in the center of the groove **248** in contact with the flat bottom **250** of the groove **248**. However, exemplary embodiments are not limited to this particular position, and the portion of material **400** may be positioned offset from the center of the groove in contact with one of the angled walls **254**.

The portion of material **400** is also not limited to a particular material and may include any clean room approved materials, such as metallic materials, resins, plastics, and rubbers. Further, the method of adding the portion of material **400** is not particularly limited and may include providing molten material and allowing it to solidify in place, or placing a solid material piece, such as a metallic bearing and gluing the solid piece in place with an adhesive. The method of application of the portion of material **400** is discussed in more detail below.

FIG. 8A is a cross-section view of a second example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. 2. FIG. 8B is a cross-section view of the second example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. 2 with a quantity of material added for imbalance correction.

This second example embodiment has some features similar to those of the first example embodiment discussed above and thus similar reference numerals are used. Specifically, the illustrated clamp **240** has a body **246** having a substantially cylindrical or annular configuration, threads **242** that may be formed on a radially inner surface **244** of the body **246** of the clamp **240**. Again, these threads **242** may be configured to engage corresponding threads (not shown) formed on a disk hub **102** (shown in FIG. 2). Additionally, a groove **848** is formed in a surface of the body **246**.

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Like the first embodiment, the groove **848** in the second embodiment may extend in a circumferential direction substantially parallel to entire the circumference of the disk clamp **240**. However, an exemplary embodiment of the present application is not limited to this configuration, and may instead extend substantially parallel to only a portion of the circumference of the disk clamp.

In the first example embodiment shown in FIGS. **3A**, **3B**, and **4-7**, the groove **248** has a quasi-V-shaped cross-section with angled sidewalls **254** and a substantially flat bottom **250**. However, as mentioned above, example embodiments of the present application is not limited to this configuration. For example, in the second example embodiment shown in FIGS. **8A** and **8B**, the groove **848** is formed to have a curved sidewall **850**. Specifically, the groove **848** is shown to have a semi-circular cross-section.

Additionally, FIG. **8B**, illustrates that a portion of material **400** has been inserted into the groove **848** to adjust the mass of the disk pack on which the disk clamp **240** is mounted so as to correct any imbalance in the assembled disk pack. As in the first embodiment discussed above, the portion of material **400** in the second embodiment is shown as having a substantially spherical shape. However, an example embodiment is not limited to this particular structure and may include alternative structures such as a tear-drop shaped structure or a hemispherical shaped structure.

Additionally, in FIG. **8B**, the portion of material **400** is shown being positioned in the center of the groove **848** in contact with the curved surface **850** of the groove **848**. However, example embodiments are not limited to this particular position, and the portion of material **400** may be positioned in contact with the curved surface **840** of the groove **848** offset from the center of the groove.

Additionally, the portion of material **400** is also not limited to a particular material and may include any clean room approved materials, such as metallic materials, resins, plastics, and rubbers. Further, the method of adding the portion of material **400** is not particularly limited and may include providing molten material and allowing it to solidify in place, or placing a solid material piece, such as a metallic bearing and gluing the solid piece in place with an adhesive. The method of application of the portion of material **400** is discussed in more detail below.

FIG. **9A** is a cross-section view of a third example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. **2**. FIG. **9B** is a cross-section view of the third example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. **2** with a quantity of material added for imbalance correction.

This third example embodiment has some features similar to those of the first example embodiment discussed above and thus similar reference numerals are used. Specifically, the illustrated clamp **240** has a body **246** having a substantially cylindrical or annular configuration, threads **242** that may be formed on a radially inner surface **244** of the body **246** of the clamp **240**. Again, these threads **242** may be configured to engage corresponding threads (not shown) formed on a disk hub **102** (shown in FIG. **2**). Additionally, a groove **948** is formed in a surface of the body **246**.

Like the first embodiment, the groove **948** in the third embodiment may extend in a circumferential direction substantially parallel to entire the circumference of the disk clamp **240**. However, an exemplary embodiment of the present application is not limited to this configuration, and may instead extend substantially parallel to only a portion of the circumference of the disk clamp.

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In the first example embodiment shown in FIGS. **3A**, **3B**, and **4-7**, the groove **248** has a quasi-V-shaped cross-section with angled sidewalls **254** and a substantially flat bottom **250**. However, as mentioned above, example embodiments of the present application are not limited to this configuration. For example, in the third example embodiment shown in FIGS. **9A** and **9B**, the groove **948** is formed to have a stepped-sidewall configuration having a flat bottom **950** and one or more steps **952**, **954**.

Additionally, FIG. **9B**, illustrates that a portion of material **400** has been inserted into the groove **948** to adjust the mass of the disk pack on which the disk clamp **240** is mounted so as to correct any imbalance in the assembled disk pack. As in the first embodiment discussed above, the portion of material **400** in the third embodiment is shown as having a substantially spherical shape. However, an example embodiment is not limited to this particular structure and may include alternative structures such as a tear-drop shaped structure or a hemispherical shaped structure.

Additionally, in FIG. **9B**, the portion of material **400** is shown being positioned in the center of the groove **948** in contact with one or more of the steps **952**, **954** formed in the groove **848**. However, example embodiments are not limited to this particular position, and the portion of material **400** may be positioned in contact with one or more of the steps **952**, **954** offset from the center of the groove.

Additionally, the portion of material **400** is also not limited to a particular material and may include any clean room approved materials, such as metallic materials, resins, plastics, and rubbers. Further, the method of adding the portion of material **400** is not particularly limited and may include providing molten material and allowing it to solidify in place, or placing a solid material piece, such as a metallic bearing and gluing the solid piece in place with an adhesive. The method of application of the portion of material **400** is discussed in more detail below.

FIG. **10A** is a cross-section view of a fourth example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. **2**. FIG. **10B** is a cross-section view of the fourth example embodiment of a disk clamp **240** for use in a hard disk drive assembly of FIG. **2** with a quantity of material added for imbalance correction.

This fourth example embodiment has some features similar to those of the first example embodiment discussed above and thus similar reference numerals are used. Specifically, the illustrated clamp **240** has a body **246** having a substantially cylindrical or annular configuration, threads **242** that may be formed on a radially inner surface **244** of the body **246** of the clamp **240**. Again, these threads **242** may be configured to engage corresponding threads (not shown) formed on a disk hub **102** (shown in FIG. **2**). Additionally, a groove **1048** is formed in a surface of the body **246**.

Like the first embodiment, the groove **1048** in the fourth embodiment may extend in a circumferential direction substantially parallel to entire the circumference of the disk clamp **240**. However, an exemplary embodiment of the present application is not limited to this configuration, and may instead extend substantially parallel to only a portion of the circumference of the disk clamp.

In the first example embodiment shown in FIGS. **3A**, **3B**, and **4-7**, the groove **248** has a quasi-V-shaped cross-section with angled sidewalls **254** and a substantially flat bottom **250**. However, as mentioned above, example embodiments of the present application are not limited to this configuration. For example, in the fourth example embodiment shown in FIGS. **10A** and **10B**, the groove **1048** is formed to have a saw-toothed cross-section with an inclined bottom **1050**. Addi-

tionally, in some embodiments, a protruding member **1052** may extend toward the center of the groove from a sidewall **1054**.

Additionally, FIG. **10B**, illustrates that a portion of material **400** has been inserted into the groove **1048** to adjust the mass of the disk pack on which the disk clamp **240** is mounted so as to correct any imbalance in the assembled disk pack. As in the first embodiment discussed above, the portion of material **400** in the fourth embodiment is shown as having a substantially spherical shape. However, an example embodiment is not limited to this particular structure and may include alternative structures such as a tear-drop shaped structure or a hemi-spherical shaped structure.

Additionally, in FIG. **10B**, the portion of material **400** is shown being positioned in the center of the groove **1048** in contact with the inclined bottom **1052** of the groove **1048**. However, example embodiments are not limited to this particular position, and the portion of material **400** may be positioned offset from the center of the groove **1048**.

Additionally, the portion of material **400** is also not limited to a particular material and may include any clean room approved materials, such as metallic materials, resins, plastics, and rubbers. Further, the method of adding the portion of material **400** is not particularly limited and may include providing molten material and allowing it to solidify in place, or placing a solid material piece, such as a metallic bearing and gluing the solid piece in place with an adhesive. The method of application of the portion of material **400** is discussed in more detail below.

FIG. **11** is a perspective view illustrating an example apparatus applying the quantity of material to an example embodiment of a disk clamp **240**.

As illustrated, an apparatus **1100** for applying a quantity of material **400** to an example embodiment of the disk clamp **240** includes a supply material unit **1102**, a control device (such as a PC or controller) **1104**, a pressure/time unit **1106**, and an injection nozzle **1108** from which the quantity of material **400** is supplied. Specifically, the control device **1104** is connected and controls the pressure/time unit **1106** and the supply material unit **1102**. Further, the injection nozzle **1108** is also connected to the pressure/time unit **1106** and the supply material unit **1102**. The control device **1104** causes the supply material unit **1102** to supply a predefined amount of material to the injection nozzle **1108** when the injection nozzle **1108** is positioned proximate to an area of the groove **248** of the clamp **240** to which the quantity of material **400** is to be provided. Further, the control device **1104** also causes the pressure/time unit **1106** pressure to the injection nozzle **1108** for a defined period of time such that the quantity of material provided by the supply material unit **1102** is propelled out of the injection nozzle **1108** and into the groove **248** of the clamp **240** to form the quantity of material **400**.

Optionally, in some embodiments, the apparatus **1100** may also include an energy unit **1110** that provides energy to the material supply unit **1102** to melt the supply material into a molten state, prior to the supply material unit **1102** providing the quantity of material to the injection nozzle **1108**. The energy unit **1110** may be a laser unit, heating unit, or any other type of unit that can be used to reduce a quantity of material to a molten state. In these embodiments, the supply material unit **1102** supplies the quantity of material in a molten state, which solidifies to form the quantity of material **400** in the groove **248** of the clamp **240**. By controlling the amount of material provided to the injection nozzle **1108**, the pressure supplied by the pressure/time unit **1106**, and the time over which the pressure is applied, the control unit **1104** may control the size of the quantity of material **400** injected into

the groove **248**. In some embodiments, the quantity of material **400** may be 100 microns in size.

However, the apparatus **1100** shown in FIG. **11** is not the only embodiment of an apparatus that can be used to provide quantity of material **400** into the groove **248** of the clamp **240**. Further, the energy unit **1110** may be omitted in some embodiments. For example, an alternative apparatus may involve a movable XY stage that may place solid pieces of material into the groove **248**, and a laser which causes the solid piece of material to become partially melted and secured in place. Further, another alternative apparatus may involve a movable XY stage that may place solid pieces of material into a portion of adhesive applied within the groove **248** by an injection nozzle similar to injection nozzle **1108**, allowing the adhesive to hold the solid piece of material in place. Other alternative apparatuses may be apparent to a person of ordinary skill in the art.

FIG. **12** illustrates a flow chart for a method **1200** of manufacturing a disk drive, according to at least one illustrated embodiment. This method **1200** will be discussed in the context of the hub **102** and the disk clamp **240** of FIGS. **2-7** and **11**. However, the acts disclosed herein may be executed using a variety of different disk hubs and disk clamps, in accordance with the described method. For example, the acts disclosed herein may alternatively be executed using the hub **102** and the disk clamp **240** of FIGS. **8A-10B**.

As described herein, at least some of the acts comprising the method **1200** may be orchestrated by a processor according to an automatic disk drive manufacturing algorithm, based at least in part on computer-readable instructions stored in computer-readable memory and executable by the processor. A manual implementation of one or more acts of the method **1200** may also be employed, in other embodiments.

At act **1210**, a disk hub **102**, a disk **104** and a disk clamp **240** are provided. The hub **102** may define a mounting surface (not labeled) and a cylindrical portion **108** having a vertical surface **202**. In some embodiments, a plurality of threads may be formed in the vertical surface of the hub **102**.

The disk clamp **240** may define a body **246**, which in some embodiments may have a plurality of threads **242** formed on a radially inner surface thereof. Additionally, a groove **248** is formed in a surface of the body **246**. Further, in some embodiments, the groove **248** extends in a circumferential direction substantially parallel to entire the circumference of the disk clamp **240**. However, an exemplary embodiment is not limited to this configuration, and may instead extend substantially parallel to only a portion of the circumference of the disk clamp. Further, in the example embodiment illustrated in FIG. **3B**, the groove **248** has a quasi-V-shaped cross-section with angled sidewalls **254** and a substantially flat bottom **250**. However, the groove **248** may have alternative structures, such as the example structures shown in FIGS. **8A-10B**.

The disk **104** may define an opening there through having an inner diameter. The disk **104** may be formed in a variety of ways. In one embodiment, the media of the disk **104** may be formed, and then the disk **104** may be stamped or otherwise machined to define the first opening.

The hub **102** may also be formed in a variety of ways. In one embodiment, the hub **102** may be machined to form the mounting surface, the cylindrical portion **108** and the vertical surface. In other embodiments, the hub **102** may be cast, molded or machined to form the mounting surface and the vertical surface. In still other embodiments, other manufacturing techniques may be employed.

Similarly, the manufacturing method of the disk clamp **240** is not particularly limited and may include machining, cast-

ing, molding, or any other methods as would be apparent to a person of ordinary skill in the art.

At act 1215, the disk 104 is positioned against the mounting surface of the hub 102. The cylindrical portion 108 of the hub 102 may be inserted through the opening formed in the disk 104 and the disk 104 may be positioned in physical contact with the mounting surface. In some embodiments, a machine vision system may help align the disk 104 and the mounting surface of the hub 102.

At act 1220, the disk clamp 240 is coupled to the disk hub 102 to provide a clamping force to the disk 104. Specifically, in the embodiment shown in FIGS. 3-7, the cylindrical portion 108 of the hub 102 may be inserted into the opening of the annularly shaped disk clamp 240. Further, in an embodiment of the disk clamp 240 having threads 242 formed on a radially inner region 244, the threads 242 may engage threads formed on the vertical surface of the cylindrical portion 108 of the hub 102. Further, the threads 242 of the disk clamp 240 may be rotated downward along the threads of the hub 102 until the disk clamp engages the disk 104 to provide a clamping force thereto.

At act 1225, after the disk clamp 240 is coupled to the disk hub 102 to write a clamping force to the disk 104, imbalance of the disk pack assembly is measured to collect imbalance data for the assembled disk pack using methods that would be apparent to a person of ordinary skill in the art.

At act 1230, using the collected imbalance data, an amount of material and orientation, in three dimensions, necessary to correct the imbalance of the disk pack assembly is calculated using methods that would be apparent to a person of ordinary skill in the art.

At act 1235, a portion of material 400 is positioned at the required orientation to correct the imbalance of the disk pack assembly. Specifically, the portion of material 400 is positioned at a location within the groove 248 of the clamp 240 there was calculated in act 1230 as the necessary location to correct the imbalance calculated in act 1225. If the groove 248 extends parallel to the entire circumference of the clamp 240, the portion of material 400 can be positioned anywhere around the groove 248 to allow finer control of the placement of the portion of material 400 as compared to an embodiment that has a groove 248 that only extends parallel to a portion of the circumference of the clamp 248. Further, if the groove 248 has angular sidewalls 254, a curved bottom 850, a plurality of steps 952, 954, or an angled bottom 1050, as shown in FIGS. 3B, 8B, 9B, 10B, the vertical placement of the portion of material 400 may also be controlled to allow the imbalance of the disk pack assembly to be corrected in three dimensions by positioning the portion of material 400 at different positions both a vertical and horizontal directions.

The placement of the portion of material may be performed by an applying apparatus such as the apparatus shown in FIG. 11. Using an apparatus, such as the apparatus shown in FIG. 11, the injection nozzle 1101 may be positioned proximate to the area of the groove 248 to which the portion of the material 400 is to be added. As discussed above, the control device 1104 could then cause the supply material unit 1102 to supply a predefined amount of molten material to the injection nozzle 1108 and also cause the pressure/time unit 1106 pressure to the injection nozzle 1108 for a defined period of time to propel the supplied material out of injection nozzle and into the groove 248 of the clamp 242 to form the quantity of material 400.

However, an example method need not use the apparatus shown in FIG. 11, or any other apparatus. Additionally, the quantity of material 400 need not be provided in a molten

state and instead could be a pre-formed portion of material that is attached to the groove 248 by adhesive.

The foregoing detailed description has set forth various embodiments of the devices and/or processes via the use of block diagrams, schematics, and examples. Insofar as such block diagrams, schematics, and examples contain one or more functions and/or operations, each function and/or operation within such block diagrams, flowcharts, or examples can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combination thereof. In one embodiment, the present subject matter may be implemented via Application Specific Integrated Circuits (ASICs). However, the embodiments disclosed herein, in whole or in part, can be equivalently implemented in standard integrated circuits, as one or more programs executed by one or more processors, as one or more programs executed by one or more controllers (e.g., microcontrollers), as firmware, or as virtually any combination thereof.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the protection. Indeed, the novel methods and apparatuses described herein may be embodied in a variety of other forms. Furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein may be made without departing from the spirit of the protection. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the protection.

What is claimed is:

1. A disk drive assembly comprising:

a disk hub;

a disk media; and

an annular disk clamp that engages a radial surface of the disk hub to couple the disk media to disk hub,

wherein the disk clamp comprises:

a body portion having a transverse hole extending through the body portion; and

a groove formed in a surface of the body portion and extending in a circumferential direction substantially parallel to at least a portion of the circumference of the disk clamp; and

a balance weight installed in the groove formed in the surface of the disk clamp, wherein the balance weight comprises a quantity of material applied in the groove.

2. The disk drive assembly according to claim 1, wherein the groove has a substantially semi-circular cross section.

3. The disk drive assembly according to claim 1, wherein the groove has a cross-section comprising one or more steps formed on a bottom thereof.

4. The disk drive assembly according to claim 1, wherein the groove has a cross-section comprising an inclined bottom.

5. The disk drive assembly according to claim 4, wherein the groove comprises a protrusion that extends from a radially inner wall of the groove toward the center of the groove.

6. A disk clamp configured to engage a disk hub to couple a disk media to a disk hub, wherein the disk clamp comprises:

an annular body portion having a transverse hole extending through the body portion, the body portion configured to engage a radial surface of the disk hub;

and

a groove formed in a surface of the body portion and extending at least in a circumferential direction substantially parallel to at least a portion of the circumference of the disk clamp; and

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a balance weight installed in the groove formed in the surface of the disk clamp, wherein the balance weight comprises a quantity of material applied in the groove.

7. The disk clamp according to claim 6, wherein the groove has a substantially semi-circular cross section.

8. The disk clamp according to claim 6, wherein the groove has a cross-section comprising one or more steps formed on a bottom thereof.

9. The disk clamp according to claim 6, wherein the groove has a cross-section comprising an inclined bottom.

10. The disk clamp according to claim 9, wherein the groove comprises a protrusion that extends from a radially inner wall of the groove toward the center of the groove.

11. A method of balancing a disk pack in a disk drive, the method comprising:

providing a disk media, a disk hub and a disk clamp having a circumferentially extending groove formed in a surface thereof;

positioning the disk media proximate to the disk hub;

coupling the disk clamp to the disk hub to apply a clamping force to the disk media;

determining an imbalance of the coupled disk clamp, disk hub, and disk media; and

attaching a quantity of material so as to be in a stationary position within the groove to correct the imbalance.

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12. The method according to claim 11, wherein the attaching a quantity of material comprises inject a quantity of molten material into the groove.

13. The method according to claim 12, wherein the quantity of molten material is injected into the groove using jet printing.

14. The method according to claim 11, wherein the attaching a quantity of material comprises attaching a bearing to the groove using adhesive.

15. The method according to claim 11, wherein the groove has an inclined surface; and

wherein the attaching a quantity of material into the groove comprises:

positioning the material along the inclined surface to correct the imbalance in three-dimensions.

16. The method according to claim 11, wherein the groove has a cross-section having one or more steps formed on a bottom thereof; and

wherein the attaching a quantity of material into the groove comprises:

positioning the material on the one or more steps formed on a bottom of the groove to correct the imbalance in three-dimensions.

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